MacBeth Quantalog
Densitometer TD-100

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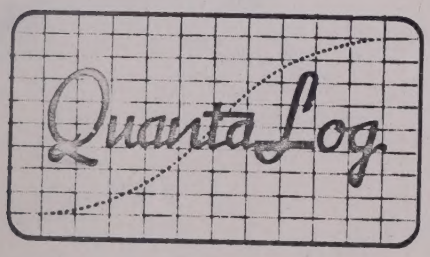
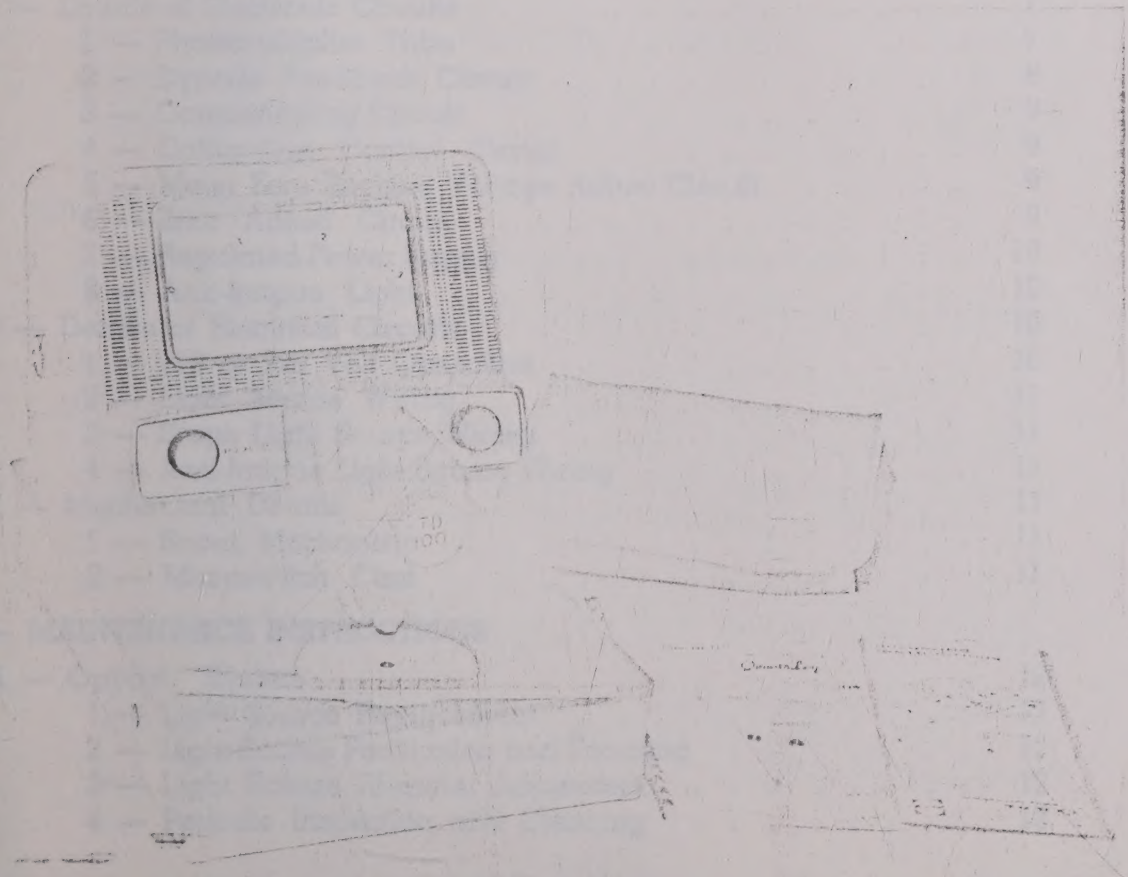


INSTRUMENTS

THIS INSTRUMENT IS LOCATED IN THE MICROFILM DEPT. #5632

OWNER'S MANUAL
FOR THE
OPERATION, MAINTENANCE, AND
TROUBLE-SHOOTING
OF THE
MACBETH QUANTALOG
Ddensitometer
MODEL TD-100



Price $5.00

Revision #6 — Mar. 1963

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— GENERAL INFORMATION

A — INTRODUCTION

This Owner's Manual, which includes trouble-shooting information, has been prepared to enable you to enjoy the optimum performance offered by your new MacbethQuantaLog® Densitometer The TD-100 has been developed to fulfill the requirements which you and other users have set forth for a precise, reliable and simple-to-operate black-and-white transmission densitometer. The information contained in this manual will serve you over the years, and the few minutes you invest now to acquaint yourself with its contents will reap rewards for you throughout the life of this fine instrument.

B — APPLICATIONS

The TD-100 has application in the Microfilm, Graphic Arts, X-Ray and Photographic Industries where precise measurement of the diffuse transmission density of materials is critical for establishing and ensuring consistent product quality.

C — GENERAL PRINCIPLES OF OPERATION

This new single-unit transmission densitometer, **for the first time,** permits any unskilled operator to make rapid, accurate, and reproducible measurements since it eliminates the operator errors and variables normally associated with conventional densitometers. This has been accomplished by limiting the number of controls to only two, and through the engineering development of a new measuring technique which prevents operator variables from affecting the precision and accuracy inherent in the optical and electronic design of the instrument itself.

The readings taken with your TD-100 indicate American Standard Diffuse Visual Transmission Density, and the linear meter scale with evenly-spaced graduations minimizes possible operator confusion.

D — OPERATING REQUIREMENTS

1 — Power Consumption

The total power consumed by the TD-100 is approximately 40 Watts. This includes the power required to operate the electronic circuits, optical light source, stage illuminator lamp and anti-fatigue lamp.

2 — Operating Voltages

The power transformer of the TD-100 has been designed for **either** 110 **or** 220 Volt operation at power line frequencies of 50 and 60 Cycles/sec. The data tag on the back of each instrument indicates the specific operating voltage for which its transformer primary has been wired. (Refer to Section III - D of this manual for instructions if this operating voltage is to be changed.)

3 — Voltage Regulation

The electronic power supply of the TD-100 is self-regulated and hence is not affected by normal line voltage variations. However, line voltage variations will affect the stability of the energy radiated by the optical system's light source. Therefore, a voltage regulator must be used to prevent these fluctuations from causing reading errors. A simple 60 Volt-Ampere voltage regulator is adequate for this purpose.

4 Ambient Illumination

The TD-100 is designed for operation under all normal conditions of ambient

nination. Its performance specifications are equally unaffected by operain either a darkroom (meter scale is not illuminated, therefore some form lumination is required when reading the scale under these conditions) or a sunlit window.

PERFORMANCE SPECIFICATIONS

– Optical

.) The geometry of the optical system meets the ASA Standard for lack-and-white diffuse transmission density, since illumination of the ample is essentially normal, and collection is diffuse.
2) Single range covering 0 - 3.0 density with no range changing reuired.
3) Precision of ± 0.02 density over entire range.
) Repeatability of ± 0.01 density over full range.

- Circular Stage Diffuser

) Brightness of approximately 75 foot-lamberts.
) Circular stage of 3¾ inch diameter.

- Aperture

) Circular aperture of 1/32 inch (0.0312 in.) installed.
) Removable for replacement (three sizes supplied).

- Samples

) Throat clearance of 11 inches so that it is possible to read the center a sample which is up to 22 inches square.
) Instrument performance is essentially independent of sample thickss.
) Maximum temperature at the measuring aperture is approximately ° C. (113° F).

ch sub-assembly of the TD-100 is inspected through its various stages of orication. After assembly, every TD-100 is operated for a period which equivalent to a minimum of several weeks of normal service. Satistory completion of this operating test qualifies an instrument for final libration and testing by our Production Department. Every instruent is then submitted to our Quality Assurance Inspectors whose acceptnce guarantees our customers that each TD-100 shipped meets the acting performance specifications described above

CCESSORIES SUPPLIED

rchase price of your TD-100 includes the following accessories (shown o on title page) which you will find enclosed in the shipping carton:

- One Instrument Dust Cover
- One Operator's Manual and Warranty Card.
- A Transparent Envelope with Simple Operating Instructions.
- An Envelope Containing One 2mm (0.0787 in.) and One 3 mm (0.118 Diameter Aperture Disc
- One Calibrated Step Tablet (0 - 3.0 Density Range)

RATING INSTRUCTIONS

FUNCTION OF OPERATING CONTROLS

perating controls for the TD-100 are located on the front of the main elec-

tronics housing (see Figure No. 1) and therefore are always in full view of the operator. The function of these controls is described below, and they should be operated in the sequence in which they are presented.

1 — Zero Adjust

This control performs a dual purpose. It is a combined power On - Off switch and ZERO ADJUST control.

(a) Rotating this switch clockwise supplies a.c. power to the instrument after it has been plugged into a suitable power line whose voltage is stabilized with a voltage regulator. (For details see Note 3 in Figure No. 5 of this manual.

(b) The ZERO ADJUST control must be rotated further clockwise to set the meter for a Zero scale reading. This is done with the snout lever in the depressed position. Note that the meter continues to read below Zero until the snout lever is fully depressed, and no sample over the aperture. This is normal and insures against an erroneous ZERO ADJUST setting. (See Section III of this manual for details.)

2 — Calibration

(a) The CALIBRATION control is used to adjust the meter pointer to read a specific up-scale density reading for which it was calibrated at the factory.

(b) Place the calibrated step tablet on the sample stage and position Step No. 18 directly over the aperture.

(c) Depress the snout lever and adjust the CALIBRATION control so that the scale reading corresponds to the density indicated for Step No. 18 of the calibration step tablet.

(d) Recheck your ZERO ADJUST setting by repeating 1 (b) above, and then recheck your calibration setting by repeating 2 (c) and 2 (d) above. Experience will indicate that this procedure can easily be accomplished in a matter of seconds.

B — WARM-UP AND PERIODIC CALIBRATION CHECKS

The TD-100 has been designed for rapid warm-up, but at least twenty minutes should be allowed to permit all components to arrive at thermal equilibrium. This is a manually-operated and manually-calibrated instrument, therefore it is recommended that the Zero and Calibration Control setting be checked several times during the day and reset when necessary to ensure that it is performing according to specifications.

C — METER READINGS

The meter has a linear 0 - 3.0 density scale (see Figure No. 1). The scale graduations are equally spaced in 0.02 density increments, and the red knife-edge pointer permits the operator to read reliably to 0.01 density units over the entire range.

D — CHANGING APERTURE DISCS

The operator may proceed to measure the density of samples after the above operating instructions have been complied with. These density measurements will be for the 1/32 inch diameter aperture disc that is normally installed in the densitometer when delivered. This aperture disc can be replaced by one of the other two larger apertures by removing the circular stage diffuser and pushing out the 1/32 inch diameter aperture disc. These aperture discs are made of

aluminum and therefore care should be exercised in making such replacements. A rod of soft material, such as wood or plastic, should be used to push the aperture discs out of the circular stage or damage to the aperture itself may result. **Note: Refer to Section IV, c for resetting the light source intensity whenever an aperture disc is changed.**

E — MAKING DENSITY MEASUREMENTS

The following simple operating instructions should be followed by an operator when using this instrument to make density measurements:

1 — Plug voltage regulator into wall receptacle.

2 — Plug TD-100 into voltage regulator.

3 — Turn ZERO ADJUST control clockwise to turn power on. (The circular stage diffuser will be illuminated).

4 — Allow at least twenty minutes for warm-up.

5 — With no sample over the aperture, depress snout lever until meter reads, and set ZERO ADJUST control for meter Zero.

6 — Position Step No. 18 of the calibrated step tablet directly over the aperture. Depress snout lever. Set CALIBRATION control for a meter reading corresponding to the density indicated for Step No. 18 on your step tablet.

7 — Recheck the meter readings obtained in 5 and 6 above and reset controls, if necessary.

8 — Your instrument is now ready for use. Proceed and make measurements of the densities of your samples.

Operating instructions are enclosed in a separate transparent plastic envelope for use by the operator, who should keep them with the instrument itself.

I — INSTRUMENT SYSTEMS PRINCIPLES AND CONSTRUCTION DETAILS

A — THEORY

The theory of operation of the TD-100 electronic circuitry is based upon the use of a photomultiplier in a feedback circuit which automatically adjusts the dynode voltage applied to a photomultiplier so as to maintain a constant anode current. The dynode voltage required to maintain a constant current for any particular amount of light falling on its photosensitive cathode is used as a measure of the optical density of a sample placed between a light source and the photomultiplier itself. Figure No. 3 is a block diagram of this over-all system. If, for example, the light flux falling upon the photosensitive surface of the photomultiplier **decreases,** as when a sample is introduced, the input signal to the voltage amplifier **decreases.** This signal is amplified and fed to the input of the power amplifier which controls the output voltage of the high voltage power supply. For the case cited, the output voltage of the high voltage power supply increases in order to maintain a constant anode current within the photomultiplier tube. The voltmeter which constantly measures this voltage will now indicate a higher voltage. Since the meter is calibrated in density units, this increase in voltage indicates an increase in density. The dynode voltage for a typical TD-100 will vary between approximately 200 and 600 Volts for samples whose optical densities fall between 0. and 3.0. This is not a completely linear relationship, however, and, therefore, a compensating circuit is used to calibrate the voltmeter readings to a given density standard.

B — DETAILS OF OPTICAL SYSTEM

1 — Imaging and Collection Optics

All details of the TD-100 optical system are schematically depicted in Figure No. 4.

The light source (L_1) used in the optical system is an incandescent tungsten lamp which has been mounted and soldered to a removable brass bracket. Energy from this light source is focused in the plane of the aperture disc by means of an elliptical reflector. The collection cone is held against the sample by a spring (not shown) when measurements are being made. The light transmitted through the sample is first scattered by a diffuser in the collection cone which is positioned nearly in contact with the sample and then reflected by the polished inside surface of the collection cone. (Note that a neoprene "O" ring is used to seal out stray light at the surface of the sample, and that stray light is excluded from the photomultiplier housing by a stray light trap located at the top of the telescoping snout mechanism). The lens serves to efficiently concentrate the light reflected from the collection cone onto the photosensitive surface of the photomultiplier tube.

A Wratten 106 visual filter is used in front of the photomultiplier tube to obtain the spectral conditions detailed by the American Standards Association for the measurement of Diffuse Visual Density. The effective density of this filter is approximately 0.4 and can be replaced for such special applications as the extending of the black and white density range to 4.0, the use of smaller apertures, or the use of spectrally selecting filters. The Macbeth Corporation will be pleased to render technical assistance in these special applications.

This optical system complies with the geometric specifications set forth by the American Standards Association in PH-2.19-1959 for the measurement of diffuse transmission density since the incident light flux is essentially specular, and all of the transmitted light is incident upon the photodetector.

2 — Circular Stage Diffuser

A circular stage diffuser is used to uniformly illuminate the sample to facilitate its accurate positioning over the aperture disc. Energy from the 15 Watt stage light source (L_3) is reflected from the diffuse surface of the stage light reflector. Only an insignificant amount of energy from this source falls upon the aperture disc, and hence density measurements are unchanged even if this source is de-energized.

— DETAILS OF ELECTRONIC CIRCUITS

he details of the electronic circuits are covered below under separate headgs which correspond to the blocks shown in the over-all system block diaam (Figure No. 3).

1 — Photomultiplier Tube

A simple phototube consists of two elements, a photo-electric emitter, or cathode, and a collecting anode, enclosed within an evacuated glass envelope. If sufficient potential is applied between these elements, current will flow through the tube when its cathode is bombarded by incident photons. This current is extremely small when the cathode is exposed to low light levels, and must be amplified by electronic circuits external to the tube itself. In a photomultiplier tube, however, amplification of the photo-electric current is accomplished by the addition of a dynode structure between the cathode and anode of the simple phototube. This structure usually consists of nine or more dynode stages, each operating at a slightly higher potential than the preceding element (see Figure No. 5). These dynodes emit copious amounts of electrons by secondary emission when excited by incident electrons. The dynodes are shaped so that the electrons leaving one dynode are guided to

the next by an electrostatic focusing action. It is possible to realize a 800,000 times amplification of the initial photocathode current within a 931-A photomultiplier tube when it is operated at approximately 100 Volts/dynode stage.

A photomultiplier tube is usually employed as a current-generating device in most circuit applications, that is, a constant dynode voltage is applied to the tube, and its current output is used as a measure of the light flux incident upon its photocathode surface (I in Figure No. 3). This relationship between flux falling on the photo cathode (I) and tube current is essentially linear. If, however, the tube current is related back to the flux that is incident upon a sample (I_o in Figure No. 3) then the relationship between I and tube current is logarithmic. In other words, if the output current of a photomultiplier tube is used in a photometer to directly measure the transmission density of a sample, then the density scale of the photometer must be logarithmic (sample density $D=\log I_o$). This is undesirable since scale markings will be spread out at low density readings, and extremely crowded at high density readings.

This undesirable situation can be overcome, however, by employing a photomultiplier tube as a constant current device and measuring its dynode voltage instead. In this circuit application, the dynode voltage is constantly adjusted electronically to maintain a constant current through the tube, regardless of the amount of light flux incident upon its phototube. The relationship between dynode voltage and optical density now becomes very nearly linear since the dynode voltage is approximately equal to the negative logarithm of the light flux incident upon the sample (I_o).

Hence, the TD-100 employs a highly sensitive photomultiplier detector in a unique dynode feedback circuit whose output is very nearly linear with transmission density. The other advantages of this circuit are described below.

2 — Dynode Feedback Circuit

There are several advantages to the use of a dynode feedback circuit for operating a photomultiplier in addition to the fact that this circuit yields a nearly linear relationship between transmission density and dynode voltage.

First, this mode of operation is tantamount to operating the photomultiplier in the conventional way, but under the ideal conditions of constant dynode voltage and with a constant level of incident flux. The result is maximum stability within the tube itself.

Second, this circuit eliminates the need for the precision-stabilized high voltage source required in conventional circuits.

Third, this feedback feature permits operation of the photomultiplier at greatly reduced dynode voltages during the periods between density readings, thereby minimizing the deleterious effects of photomultiplier fatigue (see Section III)

The photomultiplier tube in this instrument is used in a feedback loop which automatically adjusts its dynode voltage to keep the anode current constant (Figure No. 5). A signal is developed across R1 which is then amplified in the d.c. amplifier stage using a 12AU7 (V1). This amplified signal is fed to the input of a 6GW6-A power amplifier tube (V2). The plate circuit of this stage consists of the high voltage power supply, which uses a 1B3 rectifier (V3), and an impedance consisting of the dynode resistor string (R12 through R20).

If **less light flux** is received (increase in sample density) by the photomultiplier tube, then the signal appearing across R1 **decreases** (becomes less negative) This amplified signal appears at the input of V2 as a **de-**

crease in bias (grid becomes more positive) and hence the plate current V2 increases. This increases the negative voltage applied to the cathode and dynode resistor string. Therefore, the gain of the photomultiplier tube is increased and the anode current is restored to its original value.

3 — Compensating Circuit

If the operating characteristics of the dynode feedback circuit are plotted as Dynode Voltage vs. Diffuse Transmission Density, it will be seen that a perfectly linear relationship does not exist (Exhibit A). Note that the curve shown for the uncompensated dynode voltage is essentially logarithmic. Since it is desirable to obtain meter readings that are equally spaced for equal increments of density, a compensating circuit is used to obtain the instrument characteristics that are represented by the dashed - line labeled "Compensated Dynode Voltage Characteristics."

Note in Figure 5 that the microammeter, in series with a 27 K (R26) resistor and a 1.5 Meg. (R23) resistor is connected across the dynode string resistors (Point X to Ground). This is in effect a voltmeter which would yield a curve similar to the one shown in Exhibit A for uncompensated dynode voltage characteristics.

The compensating circuitry consists of three independent, parallel circuits bounded by a dashed line which shunt that portion of the dynode voltage which appears across the meter. Each contains two potentiometers known respectively as a "CUT-IN" potentiometer (R27, R29, R31) and an "EFFECT" potentiometer (R28, R30 and R32); and a diode (CR1, CR2, CR3). These potentiometers are set (see "Calibration Procedure" outlined in Section IV) at the points indicated on the curve in Exhibit A to yield a straight line for meter readings vs. diffuse transmission density.

The three cut-in potentiometers (R27, R29, R31) are connected across a zener diode (CR4) which provides a constant reference voltage of –11 Volts for the compensating circuitry. The setting of each cut-in potentiometer determines the voltage at which a particular diode will begin to conduct, and the corresponding effect potentiometer determines how much current it will conduct. For example, the setting of R27 determines when CR1 will begin to conduct, and the setting of the effect potentiometer R28 determines its conduction current. The instrument meter measures the voltage appearing between Point X and Ground.

4 — Calibration Control Circuit

The CALIBRATION control circuit which shunts the meter consists of a fixed resistor (R25) and the CALIBRATION control potentiometer (R24). This control is used as a fine adjustment for the voltage appearing across the meter while reading the density for Step No. 18 (see Section II).

5 — Meter Zero Bucking Voltage Adjust Circuit

The meter Zero bucking voltage adjust circuit consists of a fixed resistor (R21) and a potentiometer (R22) connected beween a regulated voltage of approximately 85 Volts and the instrument meter. This circuit is used as a source of bucking voltage to set up the meter Zero during initial factory calibration or when a photomultiplier tube is changed (see Section IV).

6 — Zero Adjust Circuit

The ZERO ADJUST circuit consists of a fixed resistor (R5) and a potentiometer (R4) connected to a regulated voltage of approximately 140 Volts. The setting of the ZERO ADJUST potentiometer sets the operating bias of the first amplifier tube (V1) which provides for an operator adjustment to compen-

ate for gradual aging of the light source or slight changes in circuit sensivity.

— Regulated Power Supply

he regulated power supply consists of a full-wave 6X4 rectifier tube (V4), an C filter (R11 and C2), and two voltage regulator tubes (V5 and V6). This ower supply furnishes all of the d.c. requirements for the voltage and ower amplifier stages, as well as for the compensating and bucking circuits. The high degree of circuit stability realized in this instrument is determined by the excellent regulation of this power supply. As stated earlier, an xternal line voltage regulator is required only to stabilize the intensity of he optical system light source.

— Anti-fatigue Light

ll photodetectors, including photomultipliers, may exhibit a change in their node currents with no change in the amount of incident light flux. This effect is commonly known as fatigue. Several factors affect the degree and rapidity of these changes, but fatigue in a photomultiplier appears to be principally determined by the average tube current and the material used to oat the dynode surfaces. Fatigue can be either an increase or decrease in ensitivity, although the latter is by far the most common situation.

appears that most photomultiplier fatigue is the result of a change in the econdary-emission characteristics of the dynode stages. This is probably aused by migration of cesium from the dynodes to the other surfaces within he tube, thereby effectively reducing the tube's amplifying capabilities. The ffects of this type of fatigue can be mitigated under practical operating conditions by applying the required dynode potentials only while readings are ctually being made, and by operating the tube at the lowest possible dynode voltages.

he dynode feedback circuitry of this instrument, together with an anti-fatigue ght (L_2), permits operation of the photomultiplier tube on a "standby" basis etween readings. The anti-fatigue lamp (see Figure No. 4) is positioned ext to the photomultiplier tube, and is energized through S3, a microswitch (ee Figures 5 and 6) whenever the snout lever is in the "up" position. The hield on this lamp (L_2) is rotated until the dynode feedback circuit automatically adjusts the dynode voltage at approximately 160 Volts (30 Volts less an the dynode voltage for Zero density) in the "standby" position.

he anti-fatigue light and dynode feedback circuit, together with the use of very efficient optical system, virtually eliminates the effects of photomultiplier fatigue in the TD-100.

DETAILS OF ELECTRICAL CIRCUITS

circuit details of the electrical system are covered in Figure No. 5. All input power is fed through a three-prong linecord plug. S1 is a safety interlock ch which is in the "open" position whenever the instrument cover is removsee Figure No. 8). The instrument fuse F1 is located on the rear of the Chassee Figure No. 8). S1 is the main power "On-Off" switch, located on the t, left-hand side of the electronics housing (see Figure No. 1) and is ganged with the ZERO ADJUST potentiometer.

— 115 or 230 Volt Operation

ote that the power transformer (T1) primary is shown wired for 115 Volt operation. If the instrument is to be operated from 230 Volts, this wiring must be anged in accordance with the information tabulated in "Transformer Spe-

cifications - Exhibit D," and referring to Figure No. 9.

2 — Light Source Wiring

The optical system light source (L_1) is operated from the 6.3 Volt filament winding of T1. The intensity of the light source is adjusted by the setting of R33 (screw driver adjustment).

3 — Stage Light Source Wiring

The stage light source (L_3) is a 115 Volt, 15 Watt tungsten lamp operated from one-half of the primary of T1. Therefore, the voltage rating of this lamp remains unchanged for either 115 or 230 Volt operation.

4 — Anti-fatigue Light Source

The anti-fatigue light source (L_2) is operated from the 6.3 Volt secondary of the power transformer (T_1). Power from this winding is supplied to the anti-fatigue lamp through the snout microswitch (S_3). S3 is normally closed with the collection cone in the "up" position so that the anti-fatigue light source is in operation at all times except when making density measurements.

E — MECHANICAL DETAILS

The TD-100 consists of a shallow, aluminum base frame which houses the imaging portions of the optical system, as well as the light source and reflector used to illuminate the circular stage diffuser. The light collection optics, photodetector, and all electronic components are housed in an aluminum die-casting which is permanently bolted to the 1/4 inch aluminum stage base. The instrument cover, including the perforated front and back plates, is of sheet metal construction. This cover is held in place by two knurled cover screws which fasten to the die-cast housing. The entire instrument is finished in a baked, two-tone, satin gloss metallic gray epoxy paint.

1 — Snout Mechanism

The details of the snout mechanism are shown in Figure No. 6. The probe snout is fastened to the underside of the photomultiplier housing (see Figure No. 4). The telescoping collection cone is moved within the probe snout by manually applying pressure to the snout lever through the finger rest (Figure No. 6A). A pre-determined force of approximately one pound is applied between the aperture light seal and the aperture disc by means of the snout tension spring. If the snout lever is depressed beyond the point where contact is established, a clutch override action permits the snout lever to be depressed until the cam hits a mechanical stop (Figure No. 6A). Therefore, this mechanism provides a constant pressure between the aperture seal and the aperture disc which is independent of the force applied by the operator. The collection cone is returned by the snout return spring when the snout lever is released (Figure No. 6A).

2 — Microswitch Cam

A cam is attached to the snout lever for operation of the snout microswitch (S3) (Figures 6A and 6B). One face of this cam actuates the microswitch when the snout lever is depressed and a second face serves as a mechanical stop for the snout mechanism when the snout lever is released (Figure No. 6B).

IV — MAINTENANCE INSTRUCTIONS

A — OPTICAL SYSTEM

The optical system of this instrument requires infrequent but regular maintenance and the occasions for component replacement will be rare. Instructions are given below should component replacement become necessary, together with the attendant information required for effecting replacements:

1 — Light Source Replacement

A spare light source is built into every instrument during manufacture and is located on the opposite end of the lamp bracket used to support the optical system light source (see Figure No. 4). A burned-out light source is easily replaced as follows:

(1) Remove base cover plate retaining screw.

(2) Slide base cover plate back approximately four inches.

(3) Remove circular stage diffuser.

(4) Disconnect wire supplying power to burned-out light source by separating the "quick-disconnect" connector.

(5) Remove lamp bracket retaining screw.

(6) Lift lamp bracket and rotate 180°.

(7) Replace lamp bracket retaining screw but do not screw down tightly.

(8) Re-connect wire to quick-disconnect of new lamp.

(9) Follow procedure given below for light source positioning and focusing.

2 — Light Source Positioning and Focusing

The optical system's light source is positioned by access through the bottom of the base frame, and focusing is accomplished through the stage base as follows:

(1) Let the instrument overhang your work table by about five inches.

(2) Replace the circular stage diffuser.

(3) Use the lamp bracket as a handle for positioning the light source in the horizontal plane, using the aperture disc as a target or "bull's-eye."

(4) Remove the circular stage diffuser and set the focus adjustment for a sharp image in the plane of the aperture disc. A piece of white paper will serve as a satisfactory target screen.

(5) Tighten the lamp bracket retaining screw.

(6) Replace the circular stage diffuser.

(7) Final positioning is made photometrically by depressing the snout lever and setting the light source for minimum meter reading.

(8) Replace the base cover plate.

3 — Light Source Rheostat Adjustment

The light source rheostat (R33) must be reset whenever a light source or aperture disc is replaced. This adjustment is made through an opening on the left side of the base frame, after removing a snap-in dust cap (see Figure No. 2). The following procedure should be observed for making this adjustment:

(1) Plug a voltmeter (20,000 Volt) into the dynode voltage jacks which are located on the rear of the instrument chassis (Figure No. 8).

(2) Set ZERO ADJUST control (R4) to its approximate mid-position.

(3) Depress the snout lever and set the light source rheostat with a screw

driver until the voltmeter reads 190 Volts (d.c.)

NOTE:
It is also possible to re-set the light source rheostat whenever the light source or aperture disc is replaced **without** the use of a Voltmeter as follows:

(1) Set the ZERO ADJUST control R-4 to its approximate mid-position.

(2) Depress the snout lever and set the light source rheostat with a screw driver until the TD-100 meter pointer indicates zero density.

— Periodic Inspection and Cleaning

is advisable to check the optical system on a periodic basis. The following uarterly inspection is suggested:

(1) Remove circular stage diffuser and inspect aperture disc for damage or dirt.

(2) Check light source, elliptical reflector and stage light reflector (Figure No. 4) for possible accumulation of dirt, such as dust, photographic emulsions, or moisture.

(3) Replace circular stage diffuser after cleaning and check optical focus.

(4) Check for possible light leaks at the aperture light seal by measuring Step No. 18 on your calibrated step tablet, with and without light from a flashlight falling on the aperture disc.

(5) Remove the photomultiplier housing by loosening the photomultiplier housing screw (Figure No. 4).

(6) Remove the photomultiplier tube and neutral density filter (the latter is held in place with a snap retaining ring).

(7) Inspect filter for cracks or dirt.

(8) Depress snout lever and examine collection lens Figure No. 4) for cleanliness.

All optical components may be cleaned with commercial lens cleaners, or alcohc', using a lens tissue to swab away dirt accumulations. Refer to the Replaceable Parts List if your inspection indicates the need for any component replacement.

— CIRCULAR STAGE DIFFUSER

he light source (L_3) for illuminating the circular stage diffuser is an ordinary 5W, 115 V. tungsten lamp. This lamp can be replaced by removing the base over retaining screw, and sliding the base cover plate back until the lamp an be unscrewed by hand. No lamp or reflector adjustments are required hen this lamp is replaced.

— ELECTRONICS

ll electronic components, but one, are accessible for replacement by simly removing the instrument cover (Figure No. 10). It is not necessary to reove the chassis unless R11 must be replaced. This is a 10 Watt, wire-wound esistor, however, and its failure is highly improbable.

1 — Tube Replacement

A tube layout drawing is fastened to the inside of the instrument cover as an aid in identifying each of the vacuum tubes. Note that this drawing also gives the identity and location of all potentiometers and transformers

2 — Electronic Components Board

The components of the electronics system are mounted to a board which is a separate sub-assembly. This board can be tilted back by first loosening the retaining screw located toward the front end of the chassis. (Figure No. 8). Each of the components is identified in Figure No. 7.

D — CALIBRATION

Calibration of the TD-100 is required whenever a photomultiplier tube is replaced. It is also advisable to check the calibration of your instrument, using the calibrated step tablet, whenever any other critical electrical components are replaced, such as rectifier tubes, transformers, capacitors, or diodes.
The only auxiliary equipment required to calibrate your instrument is a voltmeter which has a sensitivity of 20,000 Ohms per Volt, such as Simpson Model 262, Triplett Model 630-PL, Weston Model 980, or other comparable multimeter. The step by step procedure for calibration is as follows:

1 — Plug the TD-100 into a voltage regulator which has been plugged into the power line. (A 60 Volt Amp. voltage regulator must be selected for operation on either 115 Volt or 230 Volt, 50-60 Cycle operation).

2 — Plug the DC voltmeter into the dynode voltage jacks which are located on the rear of the chassis. (See Figure No. 8).

3 — Set ZERO ADJUST (R4) control at mid-range.

4 — Depress snout lever and set voltage adjust potentiometer (R33) which is located in the base of the TD-100. (See Figure No. 4). This is adjused with a screw driver by removing the dust cover shown in Figure No. 2. Rotate this potentiometer until the multimeter reads 190 Volts.

5 — Rotate meter zero bucking and voltage adjust potentiometer (R22) Fig. 5 and 10 for zero reading on the TD-100 meter scale with the collection cone in the "down" position.

6 — All cut-in potentiometers (R27, R-29 and R31) should be rotated fully clockwise. These controls are all located on the top of the meter bracket (see Figure No. 10) and are accessible upon removal of the instrument cover. (See drawing in cover for location of all calibration potentiometers. **Note:** Removing the cover releases the safety interlock switch (S-1), making the instrument inoperable. It will be necessary to keep this switch actuated with a rod of insulated material, such as wood or plastic, to effect calibration of the instrument.

7 — Set all effect potentiometers (R28, R30 and R32) fully clockwise.

8 — Set Calibration Control (R24) for meter reading corresponding to a step tablet density of approximately 0.45 (Step #3).

9 — Select Step No. 6 on your calibrated step tablet. This step has an indicated density of approximately 0.90.

10 — Rotate the first cut-in potentiometer (R27) counter-clockwise until you obtain a reading corresponding to the step density on the TD-100 meter scale, plus .02 density

11 — Select Step No. 9 on the calibrated wedge corresponding to approximately 1.35 density and rotate first effect potentiometer (R28) until the corresponding density is indicated on the scale of the TD-100, plus .02 density.

12 — Move to Step No. 12, which has an indicated density corresponding to approximately 1.80, and rotate the second cut-in potentiometer (R29) counter-clockwise until you obtain a reading on the scale of the TD-100 meter corresponding to this density, plus .01 density.

13 — Move the step tablet to density Step No. 15 of approximately 2.25 density and rotate second effect potentiometer (R30) until you obtain a comparable density on the meter scale of the TD-100, plus .01 density.

14 — Move to Step No. 18, which has an indicated density corresponding to approximately 2.70 and rotate the third cut-in potentiometer (R31) counter-clockwise until you obtain the indicated density reading on the scale of the TD-100 meter.

15 — Use the third effect potentiometer (R32) as a fine adjustment for the density indicated at Step No. 20.

It may be necessary to repeat the entire calibration procedure once or twice until you have attained proficiency through experience. However, the TD-100 is simple to recalibrate and its performance specifications as outlined in Section I can be quickly realized by completing the calibration procedure described above.

E — TROUBLE-SHOOTING

All trouble-shooting can be accomplished without removing the chassis from the main housing. A circuit TROUBLE-REMEDY Chart is given in Exhibit B as a guide for isolating possible malfunctions which may occur. A chart of voltage and resistance measurements is given in Exhibit C to assist in identifying individual defective components. The normal operating voltages are given in Figures 4 and 7, as well as in the Electrical and Electronic Schematic Drawing which is fastened to the inside of the instrument cover.

V — REPLACEABLE PARTS LIST

This section describes the major replaceable parts for your TD-100 which are listed as electrical-electronic, optical, and mechanical components.

All parts listed under electrical-electronic may be purchased directly from the manufacturers indicated **except** for those noted with **. Item 7, which is a 931-A photomultiplier tube must be specially selected to ensure that your TD-100 will continue to meet its performance specifications. Order this item directly from the Macbeth Instrument Corporation, indicating that it is to be used in a TD-100 instrument. All parts listed under optical and mechanical are Macbeth Instrument Corporation stock items and therefore should be ordered directly from the Macbeth Instrument Corporation or your authorized Macbeth dealer.

REPLACEABLE PARTS LIST

ELECTRICAL - ELECTRONIC

Designation	Name of Part and Description	Function	Manufacturer
V3	Tube, Vacuum 1B3	High Voltage Rectifier	R.C.A.
V1	Tube, Vacuum 12AU7	Twin Med. Mu Triode	R.C.A.
V2	Tube, Vacuum 6GW6-A	Power Pentode	R.C.A.
V4	Tube, Vacuum 6X4	B+ Rectifier	R.C.A.
V5	Tube, Voltage Reference OA2	150 V. Regulator	R.C.A.
V6	Tube, Voltage Reference 5651	90 V. Regulator	R.C.A.
V7	Photo Tube, Vacuum 931A	Photomultiplier	R.C.A.
T1	Power Transformer Cycle #M124B	Power Transformer	Cycle Transformer
R11	Resistor, Fixed, Comp. 9K Ohm, ±10%, 10 W.	B+ Volt. Divider	Koolohm
R9	Resistor, Fixed, Comp. 2.2K Ohm, ±10%, 2 W.	B+ Volt. Divider	Allen-Bradley
R23	Resistor, Fixed, Comp. 1.5 Meg Ohm, ±10%, 2 W.	High Volt Divider	Allen-Bradley
R1	Resistor, Carbon 500 Meg Ohm, ±10%, 1 W.	Grid Bias	International Resistance Co.
R10	Resistor, Fixed, Comp. 220 K Ohm, ±10%, ½ W.	Screen Bias	Allen-Bradley
R12	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R13	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R14	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R15	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R16	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R17	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R18	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R19	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R20	Resistor Same as R10	Dynode Volt. Divider	Allen-Bradley
R5	Resistor, Fixed, Comp. 82 K Ohm, ±10%, ½ W.	Grid Bias Voltage Divider	Allen-Bradley

REPLACEABLE PARTS LIST

ELECTRICAL - ELECTRONIC

Designation	Name of Part and Description	Function	Manufacturer
R7	Resistor Same as R5	Cathode Bias Voltage Divider	Allen-Bradley
R25	Resistor, Fixed, Comp. 4.7 K Ohm, ±10%, ½ W.	Hgh Volt. Divider	Allen-Bradley
R3	Resistor, Fixed, Comp. 12 K Ohm, ±10%, ½ W.	B+ Volt. Divider	Allen-Bradley
R8	Resistor, Fixed, Comp. 22 K Ohm, ±10%, ½ W.	Cathode Bias Divider	Allen-Bradley
R26	Resistor, Fixed, Comp. 27 K Ohm, ±10%, ½ W.	High Volt. Divider	Allen-Bradley
R2	Resistor, Fixed, Comp. 100 K Ohm, ±10%, ½ W.	Plate Load	Allen-Bradley
R6	Resistor, Fixed, Comp. 390 K Ohm, ±10%, ½ W.	Plate Load	Allen-Bradley
R21	Resistor, Fixed, Comp. 560 K Ohm, ±10%, 12/W.	B+ Volt. Divider	Allen-Bradley
R4 S-2	Resistor, Comp., Variable with On/Off Switch 100 K Ohm, 2W, Type JSU	Zero Adjust	Allen-Bradley
R24	Resistor, Comp., Variable 25 K Ohm, 2W, Type JU	Meter Shunt Current Adjust	Allen-Bradley
R28	Resistor, Comp., Variable 100 K Ohm, 2W, Type JU	Effect Adjust #1	Allen-Bradley
R30	Same as R28	Effect Adjust #2	Allen-Bradley
R32	Same as R28	Effect Adjust #3	Allen-Bradley
R27	Resistor, Comp., Variable 10 K Ohm, 2W, Type JU	Cut Adjust #1	Allen-Bradley
R31	Same as R27	Cut Adjust #3	Allen-Bradley
R29	Resistor, Comp., Variable 2.5 K Ohm, 2W, Type JU	Cut Adjust #2	Allen-Bradley
R22	Resistor, Comp., Variable 250 K Ohm, 2W, Type JU	Meter Zero Bucking Adj.	Allen-Bradley
C1	Capacitor, Paper 0.1 Mfd., 1600 V.	High Voltage Ripple Filter	Pyramid
C2	Capacitor, Electrolytic 20 Mfd., 450 Volt	B+ Ripple Filter	Sprague
CR1 CR2	Diodes, Dual #6RS1GC1BB1	Impedance Isolation	G.E.
CR3	Diodes, Dual #6RS1GC1BB1	Impedance Isolation	G.E.
CR4	Diode, Zener IN 1986	10 V. Reference Diode	Semi-Conductor Corp.
** L1	Lamp, #44, 6.3 V. 0.25 A. Mounted in lamp bracket	Optical System Light source	G.E.
L2	Same as L1	Anti-Fatigue Lamp	G. E.

REPLACEABLE PARTS LIST

ELECTRICAL - ELECTRONIC

Desig-nation	Name of Part and Description	Function	Manufacturer
S3	Micro-switch 11SM1	Anti-fatigue Operation	Minneapolis Honeywell
S1	Micro-switch V3-23	Safety Interlock	Minneapolis Honeywell
F1	Fuse, 3AG ½ Amp.	Overload Protection	Littelfuse
R33	Resistor, Comp., Variable 25 Ohm, 5W, WN-250	Transmission Light Source Adjustment	Centralab
L3	Bulb, Tungsten 15 W, 120 V. #15A15	Stage Illumination Light Source	GE.
	Meter, 0 - 3.0 Density 100 ua, 5600 Ohm, #1971	Density Indicator	Weston
	Line Cord Gray	Power Cord for 110 V. Operation	Macbeth
	Socket 2-06	Anti-fatigue Light	Leecraft
	Fuse Holder #341001-3AG	Power Cord Fuse for 110 V. Operation	Littelfuse

OPTICAL

Mirror, Elliptical Alzak, 1¾" Dia. #22010771	Image Optical System Light Source	Major Equipt. Corp., Chicago
Lens, Double Convex 28mm Dia., 26mm F.L. #22010751	Collecting Lens	Edmund Scientific Co.
Filter, Neutral Density (1.0 N.D.) Gelatin #96 0.860 Dia.	Establish Zero Density Operating Conditions	Eastman Kodak Co.

MECHANICAL

Screws, Cover P.D. Drawing #22010321	Retain Cover	Macbeth
Knobs, Control P.D. Drawing #22010511	Front Controls	Macbeth
Spring P.D. Drawing #22010141	Snout Return	Macbeth
Spring P.D. Drawing #22010151	Snout Tension	Macbeth
"O" Ring #5-017C147-7	Aperture Light Seal	Parker

numbers used in the above Replaceable Parts List are taken from the Total Parts List used
cation to ensure positive identification should replacement become necessary.

FIGURE 1

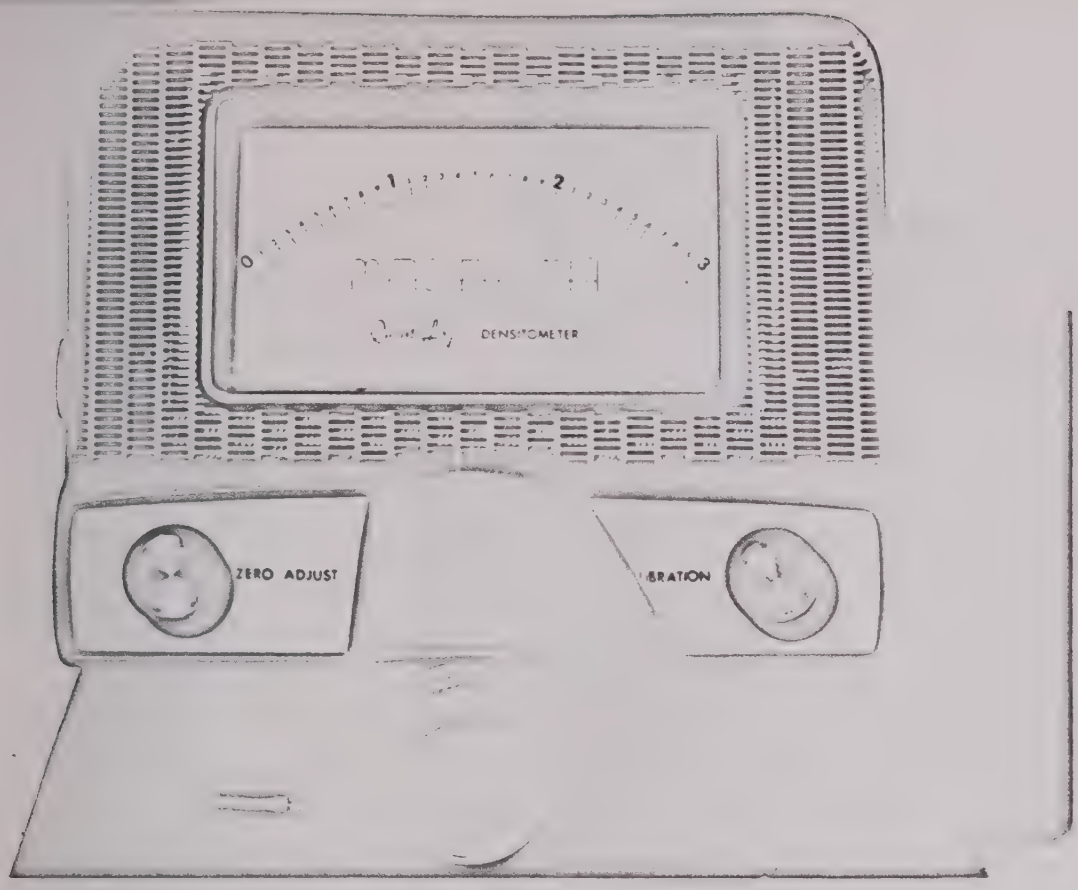
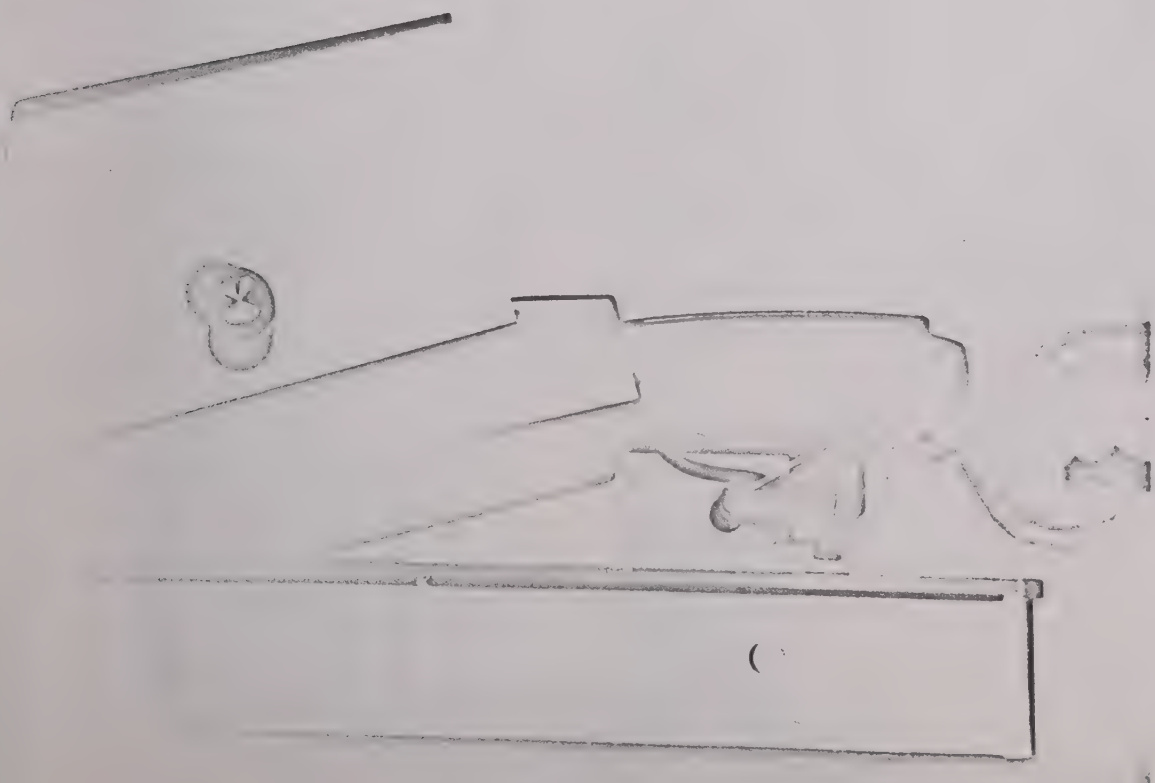


FIGURE 2



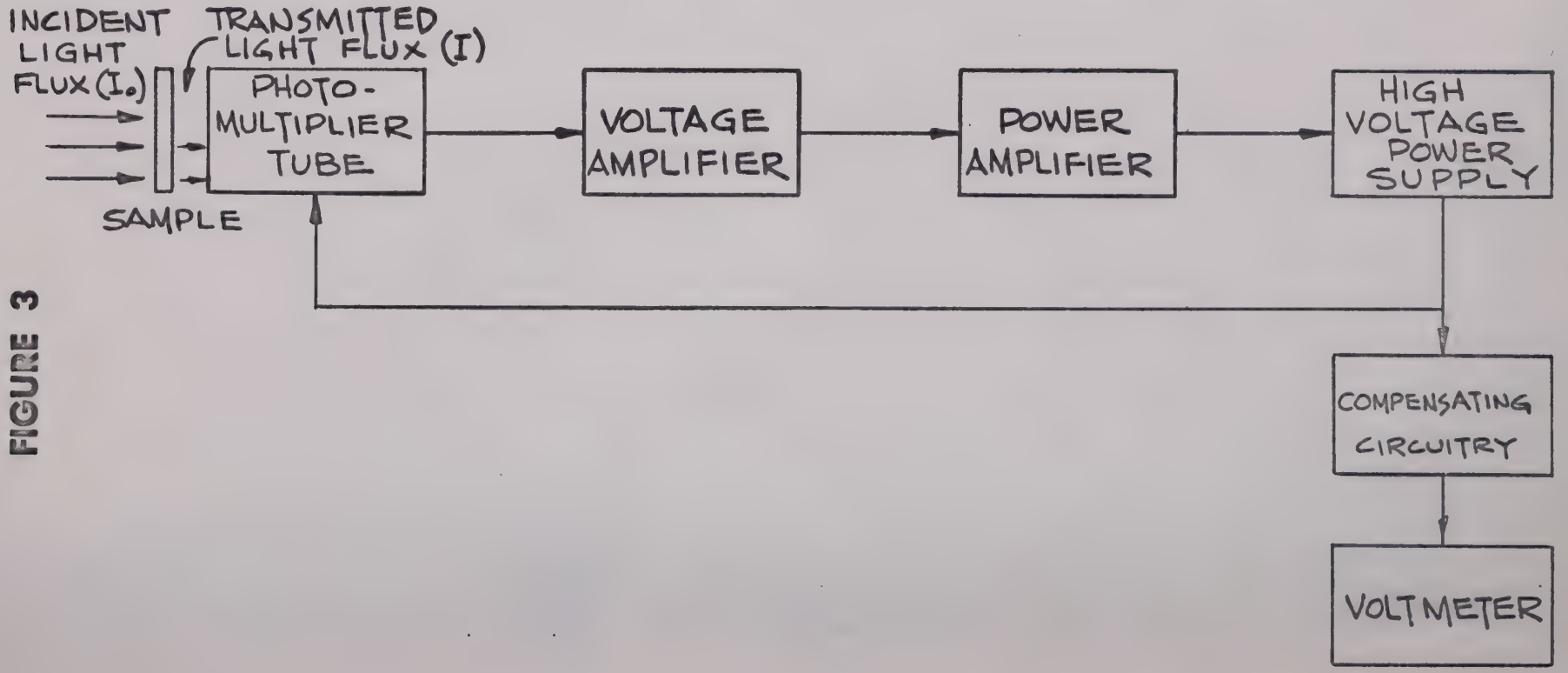
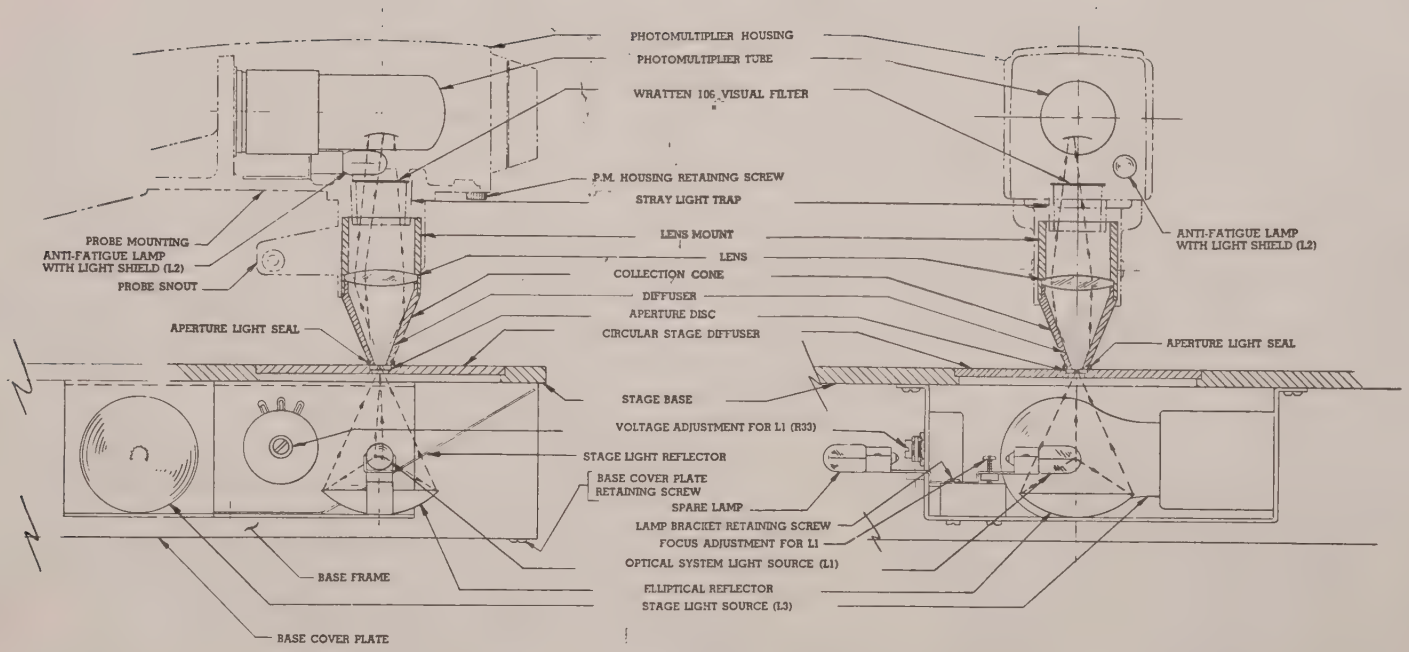


FIGURE 3

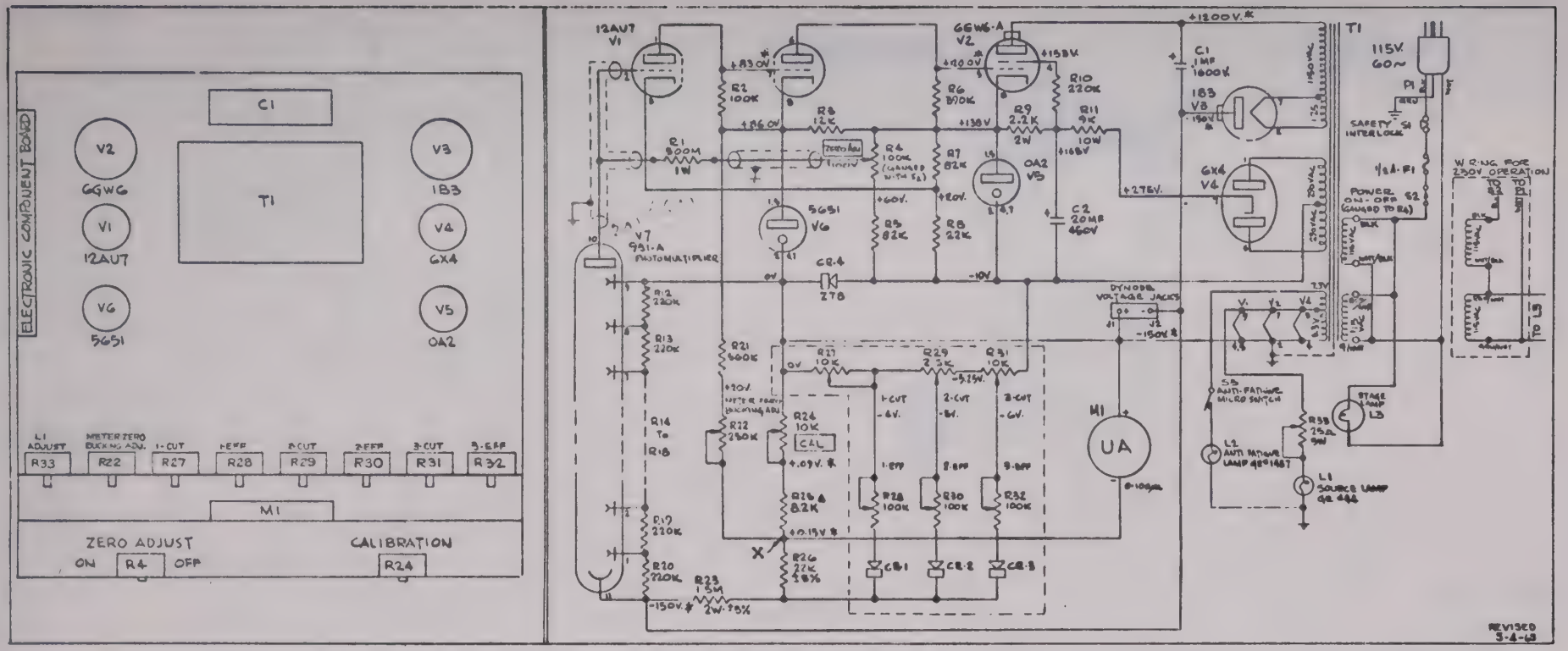
SYSTEM BLOCK DIAGRAM

FIGURE 4



OPTICAL SCHEMATIC - TD-100

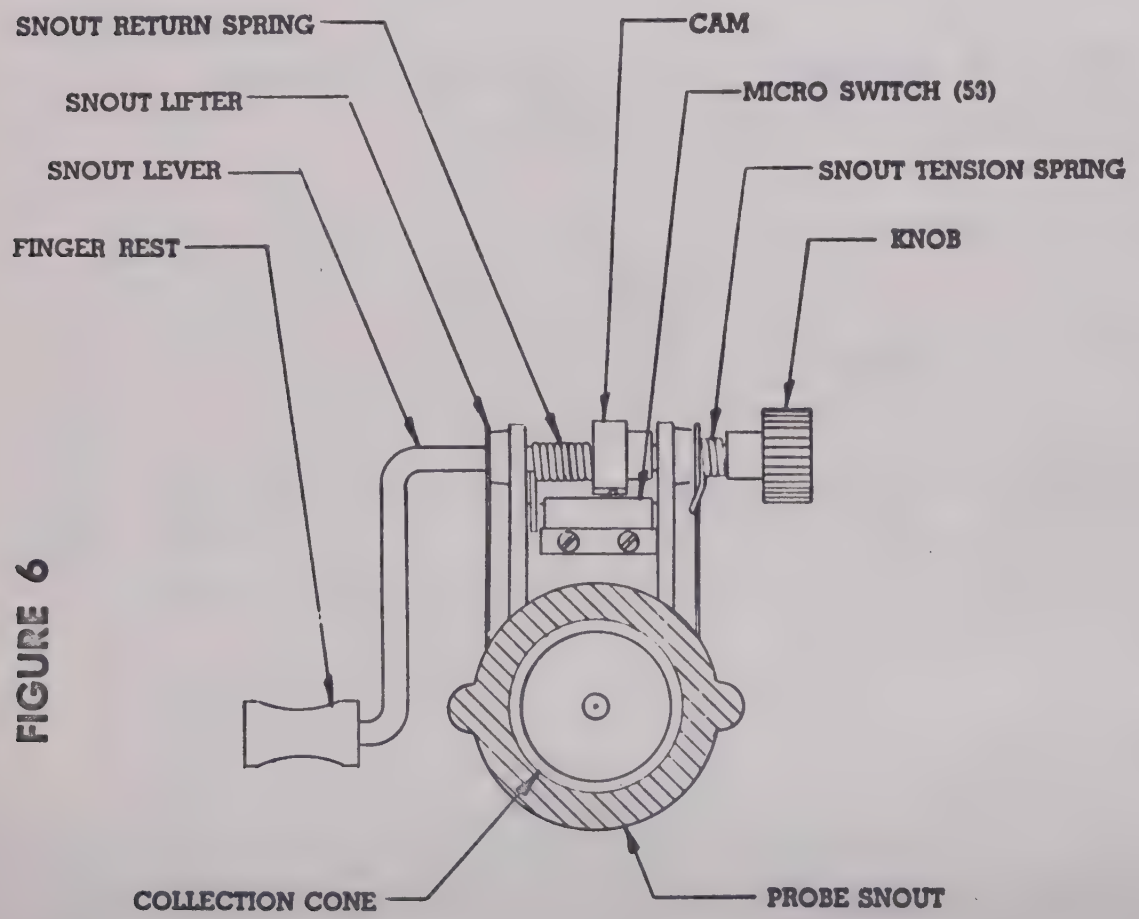
FIGURE 5



NOTES-

1. ALL D.C. VOLTAGES MEASURED WITH A 20,000Ω/V. METER TO GROUND.
2. ALL A.C. VOLTAGES MEASURED WITH A V.T.V.M.
3. INPUT LINE VOLTAGE STABILIZED WITH 60V.A. SOLA (CAT.# 20-13-060) OPERATED AT 115V.
4. ALL VOLTAGES MEASURED WITH TD-100 CALIBRATED 4 PROBE SNOUT IN UP POSITION.

* TYPICAL SIGNAL VOLTAGES WITH SAMPLE DENSITY EQUAL TO 2.0


SNOUT RETURN SPRING
SNOUT LIFTER
SNOUT LEVER
FINGER REST
CAM
MICRO SWITCH (53)
SNOUT TENSION SPRING
KNOB
COLLECTION CONE
PROBE SNOUT

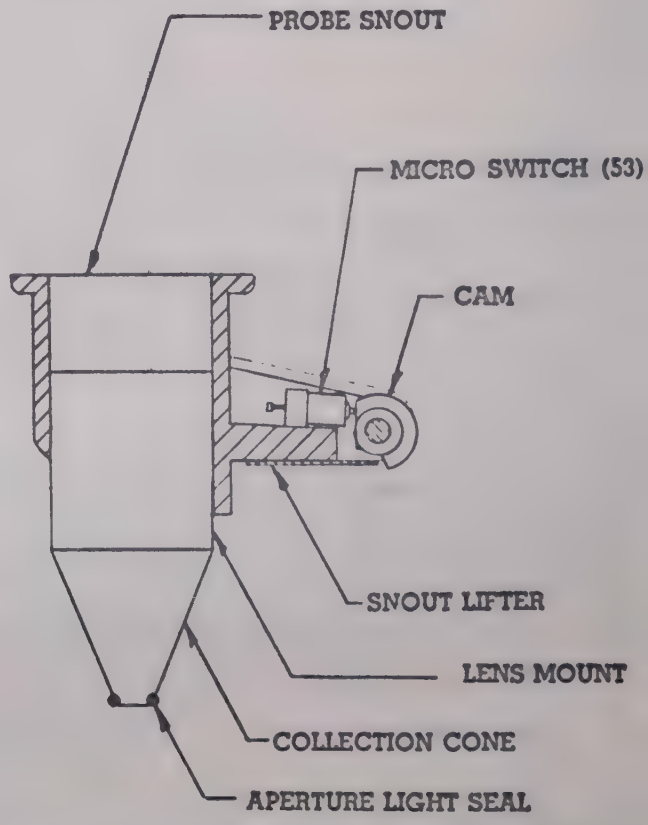

PROBE SNOUT
MICRO SWITCH (53)
CAM
SNOUT LIFTER
LENS MOUNT
COLLECTION CONE
APERTURE LIGHT SEAL

FIGURE 6

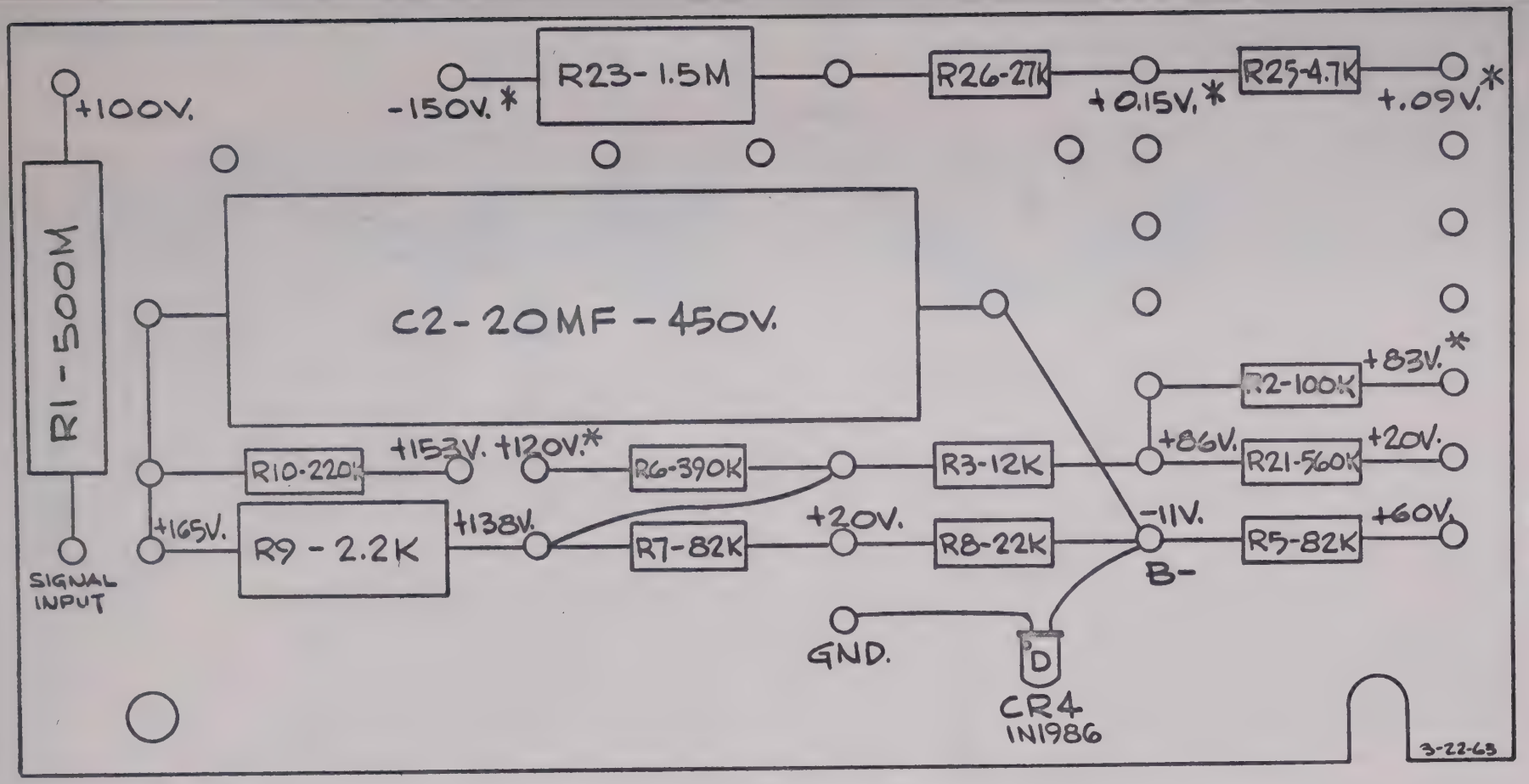


FIGURE 7

NOTES —

1. ALL VOLTAGES TAKEN WITH 20,000 OHM / V. D. C. METER TO GROUND.
2. INPUT LINE VOLTAGE STABILIZED WITH 60VA SOLA (SER. #20-13-060).
3. ALL VOLTAGES MEASURED WITH TD-100 CALIBRATED & PROBE SNOUT IN UP POSITION.

*TYPICAL SIGNAL VOLTAGES.

ELECTRONIC COMPONENTS BOARD DIAGRAM

FIGURE 8

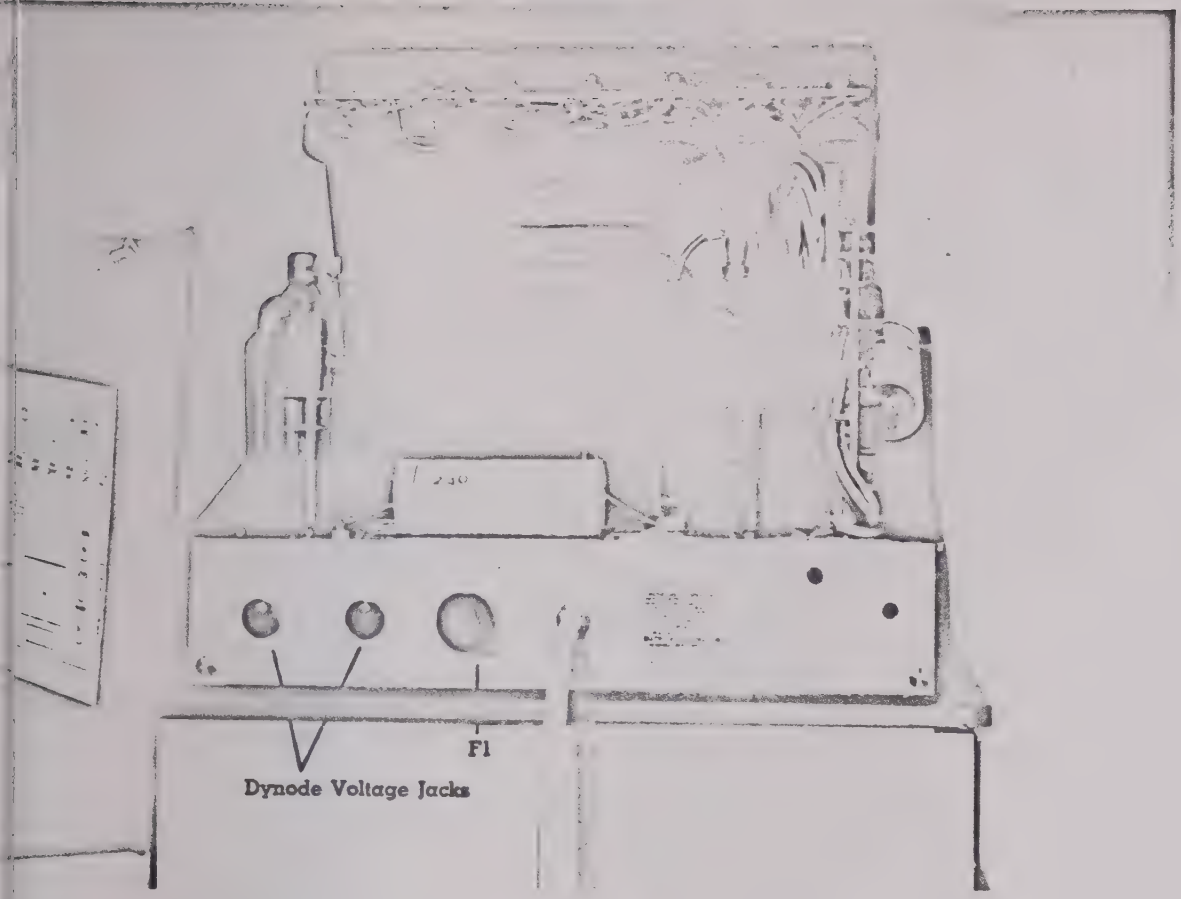


FIGURE 9

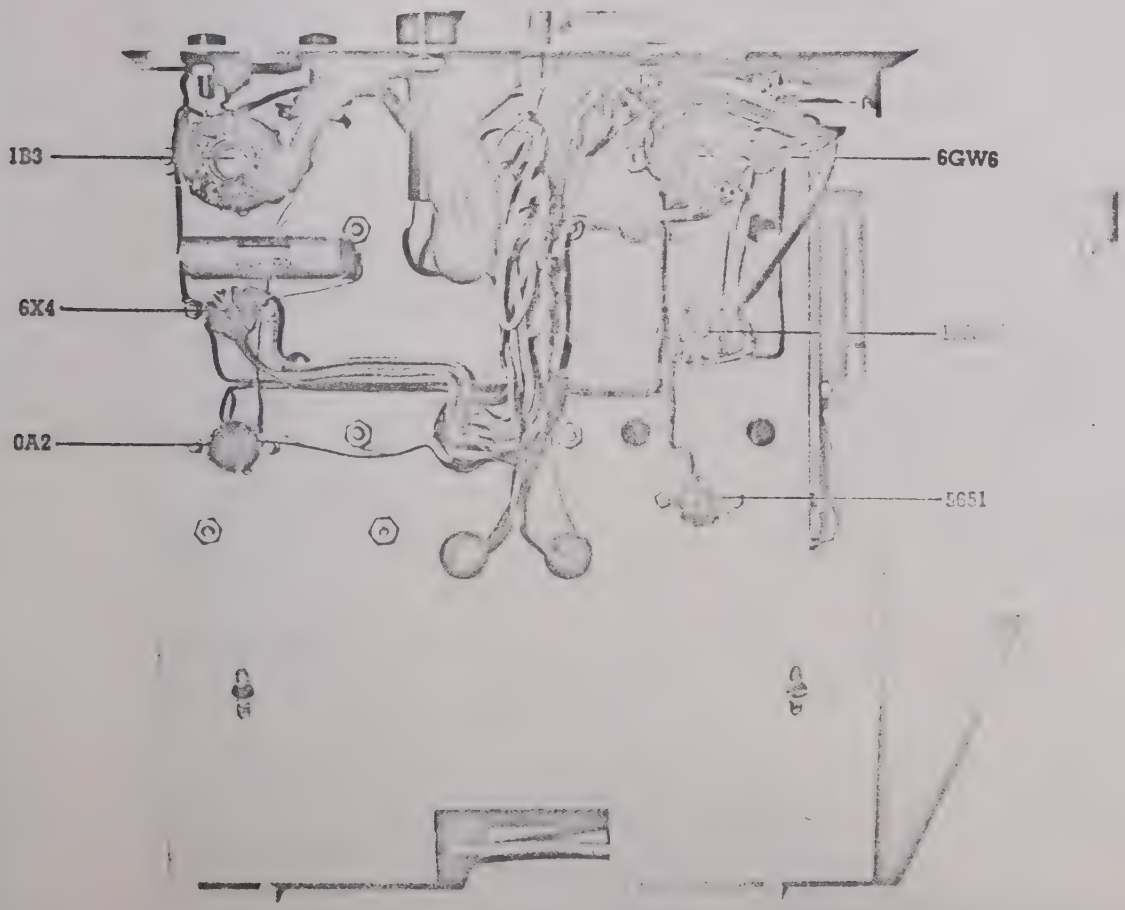


FIGURE 10

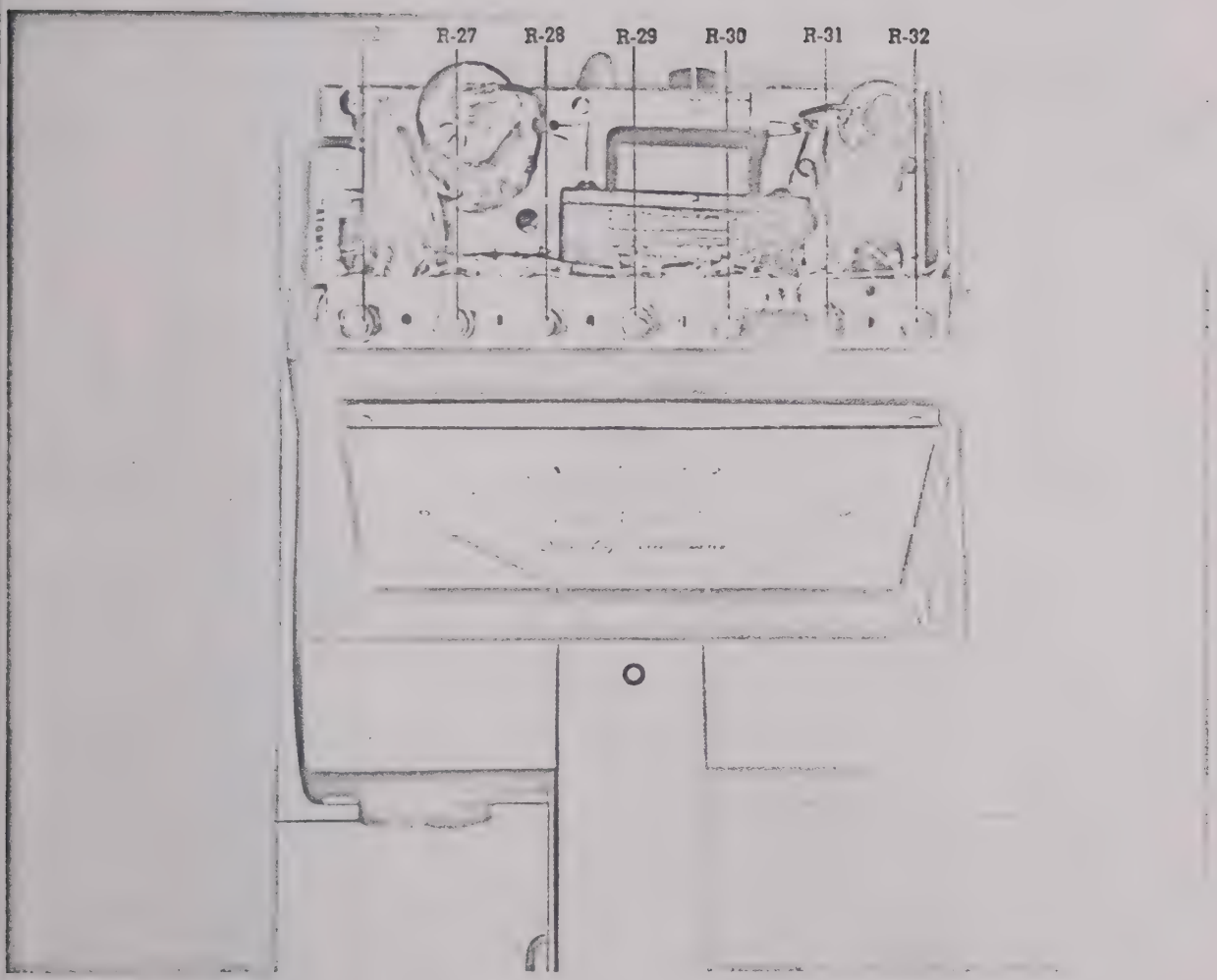


EXHIBIT A

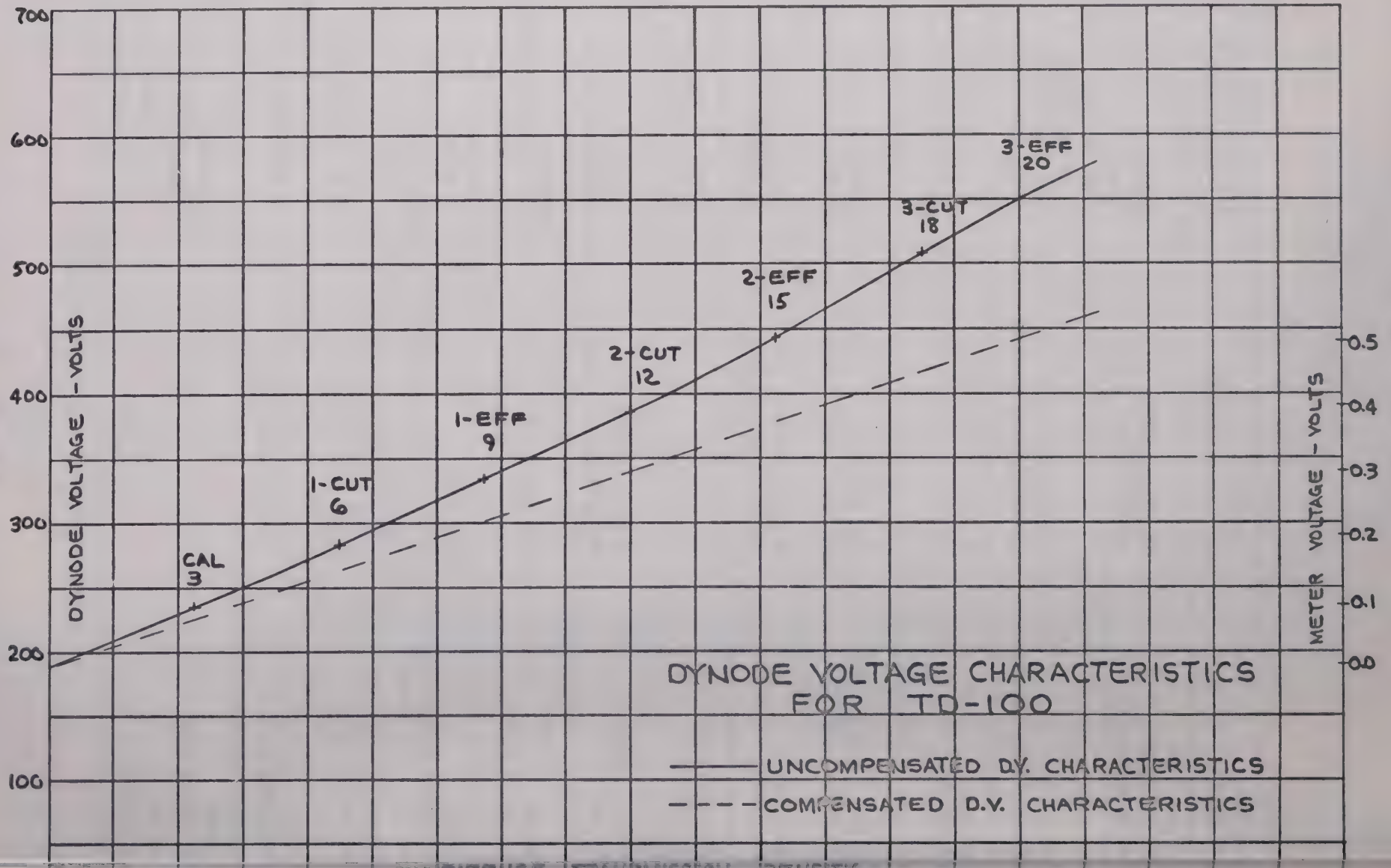

700
600
500
400
300
200
100
DYNODE VOLTAGE - VOLTS
METER VOLTAGE - VOLTS
0.5
0.4
0.3
0.2
0.1
0.0
CAL 3
1-CUT 6
1-EFF 9
2-CUT 12
2-EFF 15
3-CUT 18
3-EFF 20
DYNODE VOLTAGE CHARACTERISTICS FOR TD-100
UNCOMPENSATED D.V. CHARACTERISTICS
COMPENSATED D.V. CHARACTERISTICS

EXHIBIT B

TD-100 TROUBLE SHOOTING GUIDE

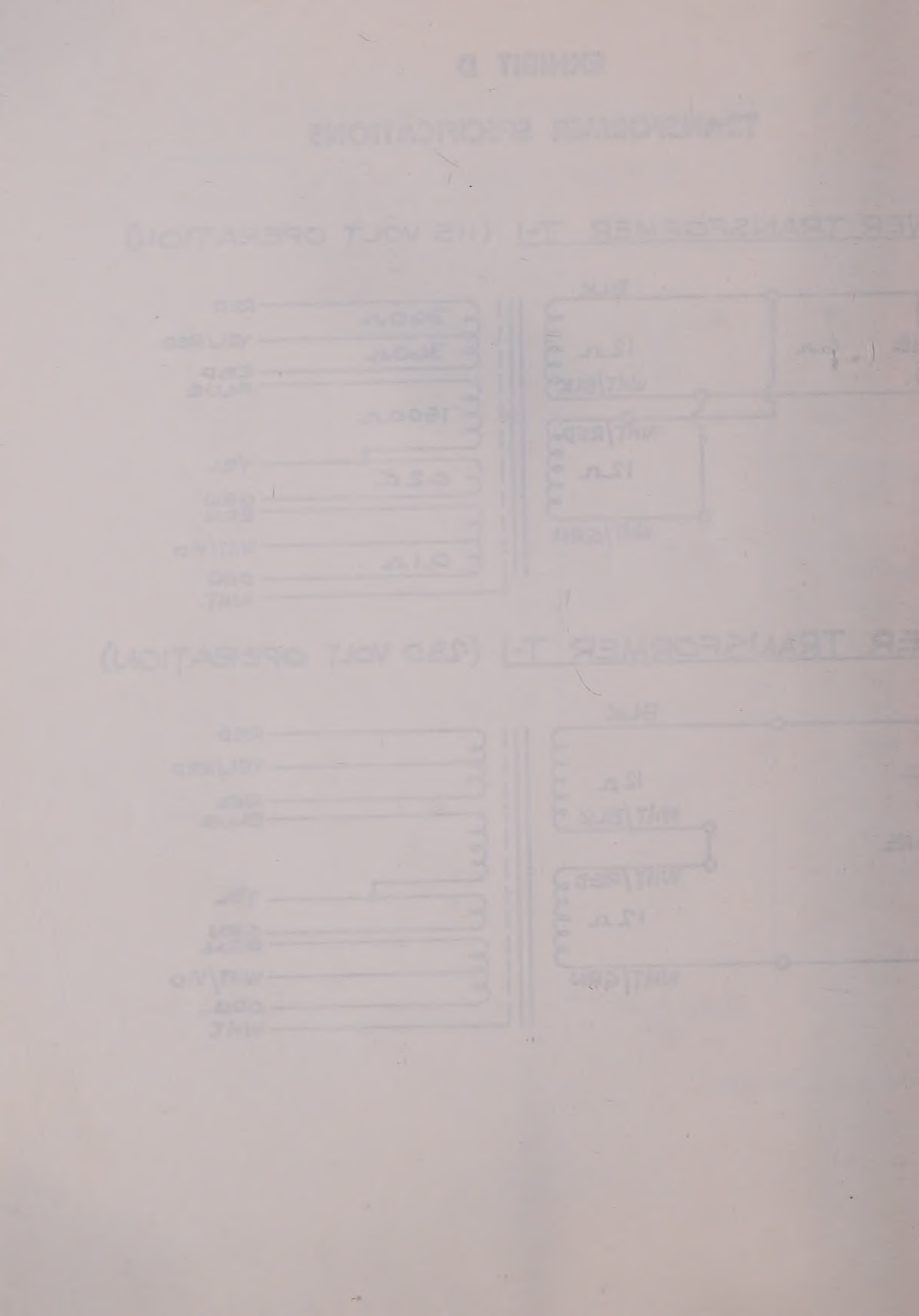
...t at Zero	Check	Fault
...er Reads High ...Scale		12AU7 Open or out of Socket
...er Reads High ...Scale	Read Approx. -30V. At 0A2 Pin-2, 4, and 7	IN1986 Open (CR-4)
...er Reads High ...Scale	Meter Reads Low off Scale when 12AU7 Pin-2 Grounded.	931-A out of socket or cable conn. open
...er Reads High ...Scale	Read Approx. + 70V at 6X4 Pin-7	6X4 open or out of socket
...er Reads High ...Scale	Read 0.0V.A.C. at 6X4 Pin-1 or 6	Transformer (T1) open. 290VAC secondary
...er Reads ...rox. 2.0 Den.	Read approx. +150V, at 5651 Pin-1,5	5651 Open or Out of Socket
...er Reads ...rox. 2.0 Den.		500 MEG. Shorted (R_1) (Approx. 1.0 MEG.)
...er Reads ...rox. Zero	Read Approx. +300V, at 0A2 Pin-1 and 5	0A2 Open or Out of Socket
...er Reads Approx. ...o, but out of Calib.	Read less than + 120V. at 0A2 Pin-1, 5	20 MF. (C2) shorted (Approx. 10K)
...er Reads ...ow Zero		500 MEG (R1) Open
...er Reads ...ow Zero	Read 0.0.V. at Dynode Volt Jacks	1B3 Open, out of socket, or open High volt. trans. winding (T1)
...er Reads Below ...o, but Dynode ...t, too High	Read Approx. +108V, at 6GW6 Pin-8	6GW6 Open or out of Socket
...er Reads ...ow Zero	Read 0.0V. at 0A2 Pin-2, 4, 7	IN1986 Shorted (CR-4) 0.0 OHMS

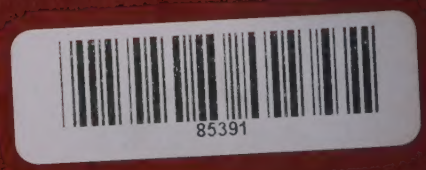
EXHIBIT C

D. C. VOLTAGE AND RESISTANCE MEASUREMENTS

Point of Measurement	D. C. Volts to Ground		Resistance to Ground (Ohms)
	Probe Up	Probe Down (2.00 Density)	
V1 - 12AU7			
Pin -1	83.0*	82.7*	190 K
2	Signal Input	Signal Input	>50 M.
3	20	20	32 K
6	120.0*	123.0*	450 K
7	83.0*	82.7*	190 K
8	86.0	86.0	70 K
V2 - 6GW6-A			
Pin -4	153	153	300 K
5	120.0*	123.0*	450 K
8	138	138	62 K
Plate Cap	1200 *	930 *	> 50 M.
V3 - 1B3			
Plate Cap	-150 *	-380 *	900 K
V4 - 6X4			
Pin -7	275	275	72 K
V5 - OA2			
Pin -1, 5	138	138	62 K
2, 4, 7	-11	-11	360 Ohm
V6 - 5651			
Pin -1, 5	86.0	86.0	70 K
2, 4, 7	0.0	0.0	0.0
V7 - 931-A			
Pin -9	0.0	0.0	0.0
10	Signal Input	Signal Input	>50 M.
11	-150*	-380 *	900 K

* Typical Signal Voltages




85391